Chemistry Quiz
Chemical Bonding
Instructor's Version

Answers to Section I (Multiple Choice)

1.	**D**
2.	**B**
3.	**C**
4.	**E**
5.	**A**
6.	**C**
7.	**E**
8.	**B**
9.	**D**
10.	**A**

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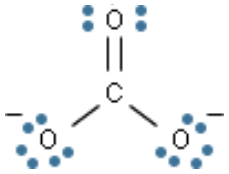
Answers to Section II (Free-Response)

Time Limit: You have 30 minutes to complete this section.
Scoring: 60 points total; question 1 is worth 30 points and question 2 is worth 30 points; points for each section are indicated within the question.

1. Consider the carbonate ion, CO_3^{2-}.

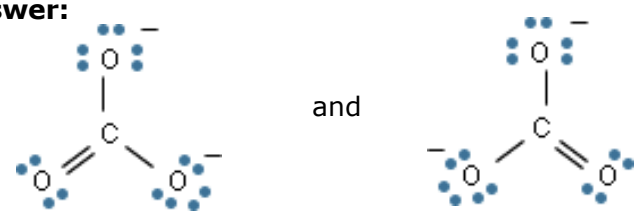
A. Draw an acceptable Lewis electron dot structure for the carbonate ion. (8 points)

Answer:



B. The carbonate ion has the property of resonance. Draw all additional resonance structures of this ion. (12 points)

Answer:



C. Would you classify the C-O bonds in the carbonate ion as pure covalent, polar covalent, coordinate covalent, or ionic? The electronegativity values of C and O are 2.5 and 3.5, respectively. (6 points)

Answer:
Polar covalent because the electronegativity difference is 1.0.

D. Estimate the C-O bond lengths in the carbonate ion, given that the average C-O single bond length is 143 pm and the average C-O double bond length is 123 pm. (4 points)

Answer:
Bond order = 1.33 so bond length will be shorter than single bond but longer than double bond. It will be about 7 pm shorter than C-O single bond, since the difference between 2 bond lengths is 20 pm and a third of this is 6.7 pm.

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2. Addition of a water molecule to a hydrocarbon containing a double bond (an "alkene") produces an alcohol. Here, the addition of H_2O to ethylene produces ethanol:

$$H_2C{=}CH_2\ (g) + H_2O\ (l) \rightarrow CH_3\text{-}CH_2\text{-}OH\ (l)$$

A. Draw the Lewis electron dot structures of ethylene and ethanol. (4 points)

Answer:

B. Calculate ΔH_{rxn} using the following data: (10 points)

Substance:	ΔH°_f:
C_2H_4 (g)	+52.7 kJ/mol
H_2O (l)	-285.40 kJ/mol
CH_3CH_2OH (l)	-277.63 kJ/mol

Answer:

	C_2H_4	+	H_2O	→	CH_3CH_2OH
ΔH°_f:	+52.7		-285.4		-277.63

ΔH_{rxn} = -277.63 – (52.7+ -285.4) = -44.9 kJ/mol

C. Calculate ΔH_{rxn} using the following data: (10 points)

Bond:	Average bond energy:
C-H	413 kJ/mol
C=C	614 kJ/mol
C-C	347 kJ/mol
O-H	467 kJ/mol
O-C	358 kJ/mol

Answer:

Bonds broken (+):

4	C-H	413 →	1652
1	C=C	614	614
2	O-H	467 →	934
			3200

Bonds formed (-):

5	C-H	413 →	2065
1	C-C	347	347
1	O-C	358	358
1	O-H	467	467
			3237

$\Delta H = \Sigma$(bonds broken) – Σ(bonds formed)
= 3200 – 3237 = -37 kJ/mol

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D. How do you account for the difference in the two ΔH_{rxn} values? (6 points)

Answer:
Difference: ΔH°_f values are exact but bond energies are <u>average</u> for a pair of atoms in wide range of molecules. Calculating ΔH with bond energies provides an <u>estimating</u>, not an exact value.

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